



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Available online at www.sciencedirect.com

Seminars in Perinatology

www.seminperinat.com

Inpatient obstetric management of COVID-19

Janice Aubey, Noelia Zork, and Jean-Ju Sheen*

Department of Obstetrics and Gynecology, Columbia University Irving Medical Center, 622 East 168th St PH 16-66, New York, NY, 10032, United States

ARTICLE INFO

ABSTRACT

Objective: To describe inpatient management strategies and considerations for pregnant patients with severe acute respiratory syndrome coronavirus 2 infection.

Findings: The novel coronavirus has posed challenges to both obstetric patients and the staff caring for them, due to its variable presentation and current limited knowledge about the disease. Inpatient antepartum, intrapartum and postpartum management can be informed by risk stratification, severity of disease, and gestational age. Careful planning and anticipation of emergent situations can prevent unnecessary exposures to patients and clinical staff.

Conclusion: As new data arises, management recommendations will evolve, thus practitioners must maintain a low threshold for adaptation of their clinical practice during obstetric care for patients with severe acute respiratory syndrome coronavirus 2 infection.

© 2020 Published by Elsevier Inc.

Antepartum considerations during the COVID-19 pandemic

The clinical presentations of pregnant patients with coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), range from being asymptomatic to being severe, requiring intensive care unit (ICU) care. Although data are still emerging, case reports and case series to date have suggested reassuring pregnancy outcomes; pregnant women have not appeared to be at greater risk for more severe disease than the general population.^{1–4} Initial evaluations must be thorough to determine an appropriate care plan. Antepartum management may be inpatient or outpatient, based on symptoms and patient stability as well as available resources.

Determination for inpatient management

A systematic review of 18 studies including 114 pregnant women infected with COVID-19 revealed the most commonly

reported symptoms to be fever (87.5%) and cough (53.8%), followed by fatigue (22.5%), myalgias (16.3%), dyspnea (11.3%), diarrhea (8.8%) and sore throat (7.5%).⁵ Breslin et al. reported that COVID-19 severity in pregnant patients is similar to that in nonpregnant patients, with 86.0% having mild disease, 9.3% having severe disease, and 4.7% being critically ill.⁴ Stable patients with mild COVID-19 infections (absence of viral pneumonia and hypoxia)⁶ can be managed as outpatients via regular outpatient telehealth video surveillance, supplemented with home monitoring of blood pressures and oxygen saturation. Treatment is mainly supportive; over-the-counter medicines may improve COVID-19-related symptoms.

Symptoms prompting urgent in-person assessment include acute-onset shortness of breath with exertion (eg walking across a room) or inability to speak in full sentences, hemoptysis, new-onset chest pain or pressure (other than pain with coughing), palpitations, signs of dehydration (eg dry mouth, dizziness when standing), and intolerance of oral intake. Patients with increased work of breathing, hypoxia (eg cyanosis of lips or fingers, pallor) and lethargy or decreased consciousness should present for hospital evaluation.

*Corresponding author.

E-mail address: js4596@cumc.columbia.edu (J.-J. Sheen).

Initial evaluation should include diagnostic testing with detection of SARS-CoV-2 ribonucleic acid via reverse transcription polymerase chain reactions (RT-PCR) from an upper respiratory specimen [acceptable specimens per the Center for Disease Control at the time of this writing include swabbing nasopharynx, oropharynx, mid-terbinates, anterior nares or obtaining a nasopharyngeal/nasal wash/aspirate^{6,7}], respiratory viral panel, fetal monitoring of viable pregnancies, vital signs, chest x-ray, complete blood count (CBC), complete metabolic profile, liver function tests, lactate, creatine phosphokinase (CPK), C-reactive protein (CRP), lactate dehydrogenase (LDH), erythrocyte sedimentation rate (ESR), ferritin, procalcitonin and an arterial blood gas (if respiratory distress is noted) (Table 1). Computer tomography (CT) scan has a high sensitivity (97%) for diagnosis of COVID-19,⁸ but its use in pregnancy may not be practical due to logistic concerns such as infection control and radiation exposures, as PCR testing become more available with improving turnaround times for results.

Criteria for inpatient admission can include persistent maternal tachycardia while afebrile (>110 bpm), fetal tracing concerns (eg tachycardia, nonreassuring fetal status), hypotension, room air oxygen saturation $<95\%$, chest imaging consistent with pneumonia, and lab abnormalities with a concerning clinical picture (Table 2). Admission should also be considered for patients who have mild disease but high risk co-morbidities. Patients at highest risk for COVID-19 include those with certain underlying conditions, such as hypertension, human immunodeficiency virus (HIV), diabetes, chronic heart disease, chronic lung disease, chronic respiratory disease, renal disease, blood dyscrasias, and conditions being treated with immunosuppressive medications, among others.⁹

Inpatients should have repeat laboratory testing and imaging based on initial results. Additional tests should include a coagulation panel, urinalysis, blood and/or urine cultures if bacterial infection is suspected, interleukin-6, high-sensitivity troponin, HIV and Hepatitis B serologies (if not previously done in pregnancy, or if new-onset transaminitis) and an electrocardiogram (Table 3). Although some of these laboratory studies are normally elevated in pregnancy (e.g. ESR, LDH, CRP), they may be useful for following the disease course. Abnormalities in infected patients can mirror those seen in other disease processes, such as preeclampsia or HELLP syndrome, gastrointestinal illnesses, other respiratory illnesses (such as influenza or pneumonia), thus concurrent workup may be prudent to ensure accurate diagnoses.

Admitted patients should be moved to the most appropriate setting for maternal care, including an adult ICU or

stepdown unit as needed. Viable pregnancies should have appropriate fetal monitoring and preparations in case emergent delivery is warranted. Care plans and management should be multidisciplinary, including maternal-fetal medicine, pulmonary/critical care and infectious disease specialists. Other services like pharmacy, respiratory therapy, physical therapy, social work, psychiatry, nutrition and care management may also be needed.

Adequate oxygenation is a primary concern for COVID-19 patients. An oxyhemoglobin saturation $\geq 95\%$ is needed to optimize fetal oxygenation. Oxygen supplementation can be provided via (in order of increasing oxygen delivery) nasal cannula (NC), Venturi face mask, non-rebreather mask, high flow non-rebreather, continuous positive airway pressure (CPAP), bilevel positive airway pressure (BPAP) and endotracheal intubation. Due to risk of aerosolization and oxygen source contamination, oxygen supplementation should only be provided to maintain maternal oxygen saturation $\geq 95\%$, not for empiric fetal resuscitation, as studies do not support this indication. Rarely, extra-corporeal membrane oxygenation (ECMO) may be required. Adequate fetal oxygenation requires a maternal arterial oxygen tension (PaO₂) >70 mmHg, with a goal PCO₂ between 35 and 40 and a pH goal of 7.4 to 7.47 to replicate normal pregnancy physiology. Overhydration may contribute to hypoxemia and should be avoided.

When patients are unable to maintain adequate oxygen saturation of 95% or greater by pulse oximeter with supplementation, intubation may be required. Typical threshold requirements would be the need for greater than 15 liters (L) per minute by NC or face mask, greater than 40–50 L per minute by high-flow NC or greater than 60% fraction of inspired oxygen by Venturi mask, or if the patient is unable to protect her airway due to altered mental status (Glasgow coma scale less than 8).¹⁰ The decision to intubate should be made with involvement of a critical care specialist and /or obstetric anesthesiologist.

Fetal monitoring

Decisions surrounding the approach to fetal monitoring should be guided by a multidisciplinary discussion, including the neonatal team. Continuous monitoring of viable fetuses in severely ill patients provides an additional maternal vital sign to guide medical management. Perivable fetal monitoring should consider the patient's desire for fetal intervention if medically feasible. Beyond the threshold of viability, decisions for fetal intervention should include discussions of the gestational age when infant resuscitation is obligatory.

Table 1 – Initial evaluation.

Nasopharyngeal Swab for SARS-CoV-2 (or other appropriate airway specimen)	Fetal Monitoring	Vital Sign Evaluation	Chest Radiograph
Complete Blood Count with Differential	Complete Metabolic Panel	Lactate	Creatine Phosphokinase Test
C-Reactive Protein	Lactate Dehydrogenase	Erythrocyte Sedimentation Rate	Procalcitonin
Ferritin	Arterial Blood Gas (if indicated)	Liver Function Tests	Respiratory Viral Panel

Table 2 – Criteria for hospital admission for pregnant women with COVID-19.

Signs/Symptoms	Findings
Shortness of breath (unable to walk across the room or speak in full sentences; increased work of breathing)	Room air oxygen saturation <95%
New-onset chest pain or pressure (other than pain with coughing)	Chest imaging consistent with pneumonia
Hemoptysis	
Inability to tolerate oral intake	Persistent maternal tachycardia while afebrile (>110 bpm)
	Evidence of dehydration (dizziness while standing, orthostatic hypotension)
Decreased level of consciousness	Lab abnormalities with concerning clinical picture
	Fetal tachycardia/ nonreassuring fetal tracing

Table 3 – Additional tests for subsequent evaluation after admission.

Coagulation Panel	Human Immuno-deficiency Virus	High-sensitivity Cardiac Troponin	Blood Cultures x 2
Electrocardiogram	Hepatitis B Serologies	Interleukin-6	Sputum Cultures (if indicated)
Urinalysis	D-dimer		

Antenatal medication considerations

Currently, no vaccinations for the prevention of COVID-19 infection exist. Although multiple medications (hydroxychloroquine, lopinavir/ritonavir, interferon β -1b, tocilizumab, sarilumab, azithromycin, convalescent plasma and remdesivir) are being trialed in patients with severe symptoms, there are also currently no proven antiviral treatments for COVID-19; decisions regarding drug use should be made with local infectious disease experts and with considerations for potential maternal and fetal risks.^{11,12} Pregnant and breastfeeding women have yet to be included in the large-scale clinical trials currently underway. Remdesivir has had promising data, showing hospitalized patients with advanced COVID-19 and lung involvement recovered faster than similar patients who received placebo, according to a preliminary data analysis from a randomized, controlled trial involving 1063 patients.¹³ Convalescent plasma also appears promising and has been used in other viral respiratory illness epidemics [H1N1 influenza, severe acute respiratory syndrome-related coronavirus (SARS-CoV), and Middle East respiratory syndrome-related coronavirus (MERS-CoV)] but is still being investigated for its effectiveness for treating COVID-19.¹⁴ When there is a suspected or confirmed secondary infection, appropriate antibiotic treatment and/or antiviral treatment should be used promptly after consultation with microbiologists.¹¹

The decision for antenatal corticosteroid administration to promote fetal lung maturity should consider the benefits and risks in the setting of the patient's illness severity and gestational age, especially in light of studies demonstrating the largest benefit from antenatal corticosteroids occurring at early gestational ages. One large prospective cohort study showed neonatal death before discharge was not significantly reduced at or beyond 31 weeks, and survival without morbidity did not reach statistical significance after 28 weeks.¹⁵ Additionally, antenatal corticosteroid administration raises concerns about worsening pulmonary status and viral shedding as seen in other respiratory illnesses, thus the Society for Maternal-Fetal Medicine (SMFM) currently recommends its use for patients at risk for preterm birth with an upper

limit of 34 weeks gestation.¹⁰ Late pre-term steroids after 34 weeks are not recommended.

Data are limited regarding the effect of nonsteroidal anti-inflammatory drugs (NSAIDs) on COVID-19 disease, but concerns for a higher risk of acute kidney injury should be taken into account. In the acutely ill COVID-19 patient, indomethacin use should be restricted for the treatment of preterm labor but nifedipine is a reasonable alternative for tocolysis, unless the patient is hypotensive.¹⁶ Preliminary evidence suggests that nifedipine may be beneficial in COVID-19 patients due to its efficacy in treating patients with high-altitude pulmonary edema, which has clinical similarities to COVID-19 lung findings.¹⁷ Tocolysis should be limited to the duration of antenatal corticosteroid administration and patients without significant COVID-19 disease.

The benefits of magnesium sulfate for fetal neuroprotection or maternal seizure prophylaxis should be weighed against the possible risk for maternal respiratory depression.¹⁸ A lower dose over a longer period of time or as a single bolus may decrease this possibility; renal function should be assessed prior to administration.¹⁸ Patients with mild preeclampsia should not receive magnesium sulfate.

Thromboprophylaxis is appropriate for virtually all admitted COVID-19 positive pregnant and postpartum patients, as for all inpatients who are not frequently ambulating. Exceptions would include active hemorrhage, severe thrombocytopenia not attributable to disseminated intravascular coagulation (DIC), preeclampsia, severe thrombocytopenia (<50,000 or as agreed upon by multidisciplinary discussion) and labor (during which sequential compression devices should be considered) (Table 4). Considerations should be made for patients who have abnormal renal function.

Delivery timing

Limited evidence exists for delivery recommendations at specific gestational ages, but the severity and temporality of the COVID-19 infection, maternal comorbidities and fetal status should be considered. In the third trimester, women with suspected or confirmed COVID-19 infection but without a medical indication for

Table 4 – COVID-19 inpatient obstetric venous thromboembolism prevention/prophylaxis.

Antepartum Patients	<p>Unfractionated heparin (UFH) 5000 units (U) administered subcutaneously (subQ) three times daily (TID) Check platelets one week after initiation</p> <p>If moderate or severe disease, continue anticoagulation for two weeks total, including outpatient if discharged</p> <ul style="list-style-type: none"> ◦ If discharged <36 weeks, use enoxaparin 40 mg subQ daily (lower risk of heparin-induced thrombocytopenia) ◦ If discharged >36 weeks or high risk for preterm delivery, use UFH as above and check platelets one week after initiation
Intrapartum Patients	Sequential Compression Devices
Postpartum Patients	<p>Initial: UFH 7500 Units subQ two times daily (BID) for the first 24 hours post-delivery at least one hour after epidural catheter is removed. An indwelling epidural catheter is not a contraindication to starting anticoagulation.</p> <p>Once no concern for bleeding/> 24 hours after delivery:</p> <p>Normal renal function</p> <ul style="list-style-type: none"> ◦ Creatinine clearance (CrCl) of > 30 mL/hr ◦ Enoxaparin 40 mg subQ daily ◦ If BMI ≥ 40 kg/m², give enoxaparin 40 mg subQ BID <p>Stage 4–5 chronic kidney disease</p> <ul style="list-style-type: none"> ◦ CrCl of < 30 mL/hr ◦ Enoxaparin 30 mg subQ daily or heparin 7500 Units subQ BID <p>At Discharge:</p> <p>Mild Disease Enoxaparin subQ prophylaxis for at least two weeks</p> <p>Moderate or Severe Disease Enoxaparin subQ prophylaxis for six weeks Check platelets four weeks after initiation</p>

delivery may have delivery postponed until a negative test result is obtained or quarantine restrictions removed, to decrease the possibility of virus transmission to the neonate.¹⁹ If the patient has another indication for delivery, her COVID-19 positive status should not cause a delay. In most cases, delivery management should be guided by usual obstetric practices, but moderately or severely ill patients may need expedited delivery if there is a need to improve maternal oxygenation.¹¹ Asymptomatic or mildly symptomatic woman positive for COVID-19 between 37 and 38 6/7 weeks gestation without other delivery indications may be expectantly managed until 14 days after her positive test result or seven days after symptoms onset and three days after symptom resolution, to allow for decreased viral exposure of health care workers and the newborn, and decreased personal protective equipment utilization in supply-limited areas.¹⁰ Patients early in their disease course at 39 weeks gestation or later may be better served by expediting delivery to decrease the risk of worsening maternal status.¹⁰ Patients who become severely ill may show initial improvement before acute clinical decompensation approximately 7–9 days from initial symptom onset. Fetal risks should also be considered, balancing the risk for hypoxic injury from prolonged maternal hypoxemia with the risks associated with delivery at a given gestational age.

Intrapartum considerations during the COVID-19 pandemic

Intrapartum considerations for COVID-19 positive patients must take into account safety concerns for the patient, her newborn, and the staff involved in their care. During a pandemic, no medical emergencies should supersede taking proper safety precautions and wearing full PPE. Careful

planning and anticipation of emergent situations can help prevent delays in medical care and avoid unnecessary exposure to the virus and secondary morbidities.

Testing, symptom stratification and delivery location

Because COVID-19 positive patients may be asymptomatic, universal testing, if available, can guide delivery management of pregnant women being admitted or transferred to labor and delivery. Early in the pandemic in the United States, testing was limited to the Center for Disease Control and then became available to state and local health departments. Institutional or commercial laboratories have increased their testing capabilities, although variable turnaround times for results remain. For institutions where results do not return in time to aid the clinical management of a patient's delivery, clinicians may resort to management strategies based on risk-stratification: persons under investigation (PUI) who are either low suspicion (no concerning symptoms) or high suspicion (symptoms suggestive of COVID-19 infection). Appropriate PPE in each of these circumstances should be determined by institutional guidance and availability, keeping in mind that N95 respirators are recommended for high-risk aerosolizing procedures. If the patients are able to receive testing with prompt results, inpatient management still can be informed by their symptoms. For example, those with negative tests but concerning symptoms would be treated as if they were COVID-19 positive or a PUI with high suspicion. In areas of high prevalence, it is important to recognize that as many as one in eight asymptomatic pregnant patients may test positive for COVID-19.²⁰

The location for a COVID-19 positive woman's labor management largely depends on the same risk stratification and

resource availability, varying from negative pressure labor and delivery rooms to an ICU. Clinical management in a labor room would include: low-suspicion PUIs, high-suspicion PUIs with stable symptoms and vital signs, and asymptomatic or mildly symptomatic COVID-19 positive patients. PUIs with concerning/high suspicion symptomatology and COVID-19 positive patients with moderate-severe disease would be considered for ICU care.

Personal protective equipment

For clinical interactions with patients who are PUIs or who test positive for COVID-19, healthcare personnel should implement droplet and contact precautions and don appropriate PPE, including gown, gloves, surgical mask, face shield or goggles, especially for prolonged interactions close to the patient (less than six feet away).¹⁸ Personal protective equipment supply availability and local epidemiology may require alternative practices; if possible, PUIs or COVID-19 positive women should wear a surgical mask at all times to decrease risk.¹⁸ Appropriately-fitted N95 masks, if available, should be used for high-risk obstetrical situations, such as aerosolizing procedures and deliveries in the operating room (OR).¹⁸

Clinical situations warranting patient re-testing

Because a number of medical conditions have findings overlapping with those of COVID-19, patients with prior negative testing may warrant re-testing if new symptoms arise during admission; the validity duration of Sars-CoV-2 testing has not yet been determined. Conversely, for patients who have previously tested positive, new-onset or worsening symptoms considered part of the spectrum of COVID-19 disease but also attributable to other causes should still be evaluated to ensure another etiology is not overlooked. Among these include febrile illness, severe preeclampsia/HELLP syndrome, and gastrointestinal illness.

Febrile illness can encompass a number of infectious processes occurring during parturition, such as chorioamnionitis/endometritis, pyelonephritis, influenza, non-COVID-19 pneumonia, among others. While COVID-19 re-testing results are pending, clinicians should continue routine work-up and treatment for the primary etiology suspected. If other respiratory pathogens are found, infection control procedures may be different than for patients without co-infection.

Severe preeclampsia and HELLP syndrome have findings/laboratory abnormalities overlapping with COVID-19 infection as discussed previously. Transaminitis, elevated LDH, decreased platelets, abnormal coagulation studies, abnormal renal function tests and neurologic findings are among those shared by both disease processes. COVID-19 should always be considered in a patient who is suspected of having HELLP syndrome when there is community spread of coronavirus. Gastrointestinal illnesses also can cause elevated liver enzymes, in addition to loose stool (also attributable to COVID-19 infection). Evaluation and treatment for all possible etiologies should be considered until the primary cause is determined.

Considerations for asymptomatic patients with positive results prior to delivery admission

Depending on local prevalence and resources, testing for SARS-CoV-2 should be considered for all admitted patients as described above. However, as the pandemic has progressed, more patients are presenting for delivery with a history of positive testing remote from the delivery admission. Although management for these patients can change as more information is discovered about the evolution of the disease process, one possible approach for determination of the appropriate infection control procedures during the delivery admission considers the timing of the patient's first positive test, her repeat testing during admission and the testing of her infant at 24 hours of life. Assuming their infants have negative COVID-19 testing at 24 hours of life, asymptomatic mothers who have one negative test four weeks from her first positive test, or who have two negative tests 24 hours apart, after 14 days but less than four weeks from her first positive test, do not need COVID-19 infection control precautions. Determination of appropriate infection control management for these patients should be made with the participation of infectious disease specialists at the institution.

Considerations for delivery

For anticipated vaginal deliveries, designated rooms should have clear signage indicating droplet and contact precautions. Negative pressure rooms are preferred, although not required. To avoid contamination, supplies and PPE should be kept outside of the room in an easily accessible location. Labor length (and associated factors, such as parity, cervical exam, prior cesarean, etc.) and mode of delivery should be considered. Although in most cases labor management should follow usual obstetric practices, moderately or severely ill patients may need expedited delivery to facilitate treatment for COVID-19. Mildly ill patients may have vital signs taken every two hours and those with moderate symptoms every hour, both with continuous oxygen saturation evaluation. Over-hydration should be avoided and strict fluid measurements performed hourly. No data has supported one labor induction or augmentation method over the others, but anticipating the patient's COVID-19 course may help inform decision-making.

Advanced planning and early transport to the OR for operative vaginal delivery or cesarean will prevent unintended staff exposure to COVID-19 during emergent transport and delivery. Early epidural labor analgesia can minimize the risk for general anesthesia if an urgent cesarean is needed. Internal monitors (eg fetal scalp electrodes, intrauterine pressure catheters) may be placed to optimize fetal monitoring, as there is no current data suggesting vertical transmission of SARS-CoV-2 with their use or with amniotomy.¹⁸ An assisted second stage of labor should be considered in the setting of maternal exhaustion or increasing hypoxia while pushing.

Transporting a patient with COVID-19 to and from the OR (or any other location) should involve two people in full PPE as described above (gown, gloves, mask, eye shield or goggles) while an additional 'sweeper,' wearing an appropriate mask, clears the travel path and alerts people to keep six feet away

from the patient. The sweeper also opens doors and presses elevator buttons along the path. The OR should have clear infection control signage on the door and contain only necessary equipment and supplies. Cabinets should stay closed for the case duration, with additional equipment and supplies outside of the room to avoid contamination. Operating room staffing should be deliberate and limited to those essential to the case. A 'runner' designated outside of the room should be available to pass any needed medications/equipment to those inside when necessary. All staff should wear an N95 mask if available, given the potential for aerosolization during intubation should the need arise for general anesthesia. Pediatric teams should be alerted to the patient's COVID-19 status with enough time for them to don appropriate PPE.

Postoperatively, the patient should return to a single room with a closed door. If there are multiple patients with COVID-19 infection and no available single rooms, a multi-bed post-anesthesia care unit may be used if appropriately spaced, but newborns should not stay with patients. Operating room downtime during post-procedural cleaning may be prolonged due to air circulation concerns and special cleaning techniques, which must be considered during case planning.

Peripartum medication considerations

Patients with COVID-19 should avoid certain medications commonly used during parturition, due to increased risks posed by the disease process. For example, if other uterotonics are available during a postpartum hemorrhage (PPH), they should be used preferentially over carboprost due to the increased bronchospasm risk. Prophylactic tranexamic acid should also be avoided due to risk for microthromboemboli, although it may be considered for PPH management on a case-by-case basis. Preemptive post-delivery prophylactic misoprostol and oxytocin may be administered to decrease PPH risk.

Postpartum considerations during the COVID-19 pandemic

Neonatal staff should attend all deliveries of COVID-19 positive patients for prompt newborn assessment. There is insufficient evidence to suggest that common immediate post-delivery neonatal procedures, such as delayed cord clamping or abbreviated skin-to-skin contact (with the mother wearing a mask), increase the risk of infection. Institutions should consider whether to continue these practices based on evolving evidence and consultation with each patient prior to delivery. Weighing the infant and administering vitamin K and erythromycin should occur per usual practice. All instruments used to obtain vital signs for the newborn, including the scale and thermometer, should be dedicated to the use of that infant and thoroughly cleaned prior to use with other patients.

Asymptomatic patients or those with mild COVID-19 disease can be managed on a postpartum floor without invasive monitoring capability. Mothers and infant(s) remaining together can be transported to a single postpartum room with a door, with the infant in a covered system such as an isolette. Clustering COVID-19 positive patients within a

designated unit or area is preferred, to enforce appropriate infection control procedures and secure PPE in a designated area. Clustering permits apportioning a specified care team to these patients, limits the traffic between COVID-19-incongruous patients and increases vigilance with PPE donning/doffing processes.

As during labor, vital signs should be assessed with greater frequency in COVID-19-positive patients for the remainder of the hospital stay depending on the patient's disease severity. Patients with oxygen saturation <95% should have prompt clinical evaluation and hourly vital sign assessments. Daily clinical evaluation for symptom progression and pulmonary findings may lead to relocating the patient to an area with more intensive monitoring.

Postpartum medication considerations

Limited data suggest COVID-19 positive patients should receive thromboprophylaxis post-delivery, taking into account bleeding risks, kidney function, BMI and severity of symptoms. One approach for symptomatic or mildly symptomatic patients would be to continue thromboprophylaxis for at least two weeks post-delivery. Extended prophylaxis lasting six weeks should be considered for patients with moderate or severe disease (Table 4).

NSAIDs should be used with caution for symptomatic COVID-19 positive patients and those asymptomatic with a history of chronic kidney disease, as discussed above. Alternative pain medications include epidural morphine, lidocaine patch, oxycodone or gabapentin. A non-neuraxial nerve block may be considered for post-surgical patients. Patients with liver enzyme abnormalities should avoid acetaminophen.

Similar to patients with other infectious diseases, a postpartum patient with suspected or confirmed COVID-19 should defer immunizations until fully recovered from illness.²¹ Vaccine reactions may be attributed erroneously to the COVID-19 infection, with some COVID-19 positive patients demonstrating an exaggerated immune response.

Postpartum rooming considerations

Co-locating or separating healthy infants from their asymptomatic or mildly symptomatic COVID-19 positive mothers are both options during the postpartum stay. Whether a mother and her infant(s) should remain together or separate after delivery should be decided collaboratively, with consideration for a mother's desire to breastfeed, her ability to maintain separation after discharge and the facility's capability to accommodate the patient's choice.²² As stated above, contact precautions and appropriate PPE should be maintained until the requisite negative test results are obtained for both the mother and her infant. Mothers choosing to room-in with their infants should be able to care for the newborn with postpartum staff assistance. The infant should remain in an isolette greater than or equal to six feet from its mother, unless she is performing newborn care activities. Vigilant hand and breast hygiene should occur prior to breastfeeding or expressing/pumping breastmilk; a mask should be worn for breastfeeding and thorough breast pump cleansing should occur after each use.²² Mothers may elect to

have uninfected family members feed expressed milk to the infant.

Institutions lacking single rooms may cohort patients with COVID-19 infection as other medical-surgical units and ICUs have done. It is not recommended that infants room-in when rooms are shared. Infants of mothers who are critically ill or who express concerns about potential exposure risks should be placed in a dedicated nursery for infants with COVID-19 positive mothers. They should remain in their isolettes unless activities require them to be brought out. A dedicated clinical team is preferred. If not possible, care should be taken to avoid cross-contamination. Nursery video monitoring can be used to assess vital signs and activity to limit exposure. Mothers should know prior to opting for nursery placement that the infant should not leave until hospital discharge; they may view their infants via video connection during their stay.

As patients who are remote from their original diagnosis receive testing and subsequent clearance from COVID-19 precautions during their delivery admissions, determination of the appropriate infection precautions for the newborns is needed. One proposed strategy lifts precautions after a newborn test result is negative at greater than 24 hours of life.

Discharge planning considerations

Discharge planning coordination is essential for the safe discharge of patients with COVID-19 infection and their infants. Access to resources (food and other necessities) as well as the ability to engage in self-care and/or access appropriate caregivers should be assessed. Patient education regarding transmission risks at home should be discussed, including distancing from other family members in separate rooms, avoiding activities outside of the home, and maintaining respiratory and hand hygiene. Patients should be discharged with a mask, pulse oximeter and thermometer, if none available at home, to monitor symptoms. For patient with mild symptoms, discharge can be considered when fever and vital signs are stable for 24 hours, respiratory rate < 20/min (measured by direct visualization) with a resting oxygen saturation >92% on room air. Patients with oxygen saturation >92% but <95% should receive a pulse oximeter. Patients meeting the criteria above with a resting oxygen saturation >92% on two liters of oxygen via NC can be discharged home with ambulatory oxygen supplementation. Outpatient visiting nursing can provide ongoing surveillance for this group with special discharge planning considerations for patients with comorbid illnesses as previously described. Telehealth, remote monitoring or telephone calls can be utilized for regular follow-up of discharged patients, with precautions as described above for outpatient antepartum management. Patients may discontinue home isolation when afebrile for at least 72 h without antipyretic medications, at least seven days have passed since initial symptoms and other symptoms have significantly improved.

Conclusion

The COVID-19 pandemic has presented novel challenges to modern obstetric care, due to the wide range of possible

clinical presentations in pregnant women and rapidly changing management recommendations as new information arises. Inpatient obstetric care can be informed by risk stratification, severity of disease, and gestational age, taking into account local epidemiology and available resources. Clinicians must be vigilant in following evolving recommendations and maintain a low threshold for adaptation of their obstetric practice to these changes.

Disclosure

The authors report no conflicts of interest.

REFERENCES

- Chen H, Guo J, Wang C, et al. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. *Lancet*. 2020;395(10226):809–815. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/32151335>.
- Liu Y, Chen H, Tang K, Guo Y. Clinical manifestations and outcome of SARS-CoV-2 infection during pregnancy. *J Infect*. 2020 Available at <https://www.ncbi.nlm.nih.gov/pubmed/32145216>.
- Breslin N, Baptiste C, Miller R, et al. COVID-19 in pregnancy: early lessons. *Am J Obstet Gynecol MFM*. 2020 [In Press]. Available at: <https://www.sciencedirect.com/science/article/pii/S2589933320300410?via%3Dihub>.
- Breslin N, Baptiste C, Gyamfi-Bannerman C, et al. COVID-19 infection among asymptomatic and symptomatic pregnant women: two weeks of confirmed presentations to an affiliated pair of New York City hospitals. *Am J Obstet Gynecol MFM*. 2020;100118 Available at: <https://www.ncbi.nlm.nih.gov/pubmed/32292903>.
- Yang Z, Wang M, Zhu Z, Liu Y. Coronavirus disease 2019 (COVID-19) and pregnancy: a systematic review. *J Matern Fetal Neonatal Med*. 2020 Apr 30:1–4.
- Center for Disease Control and Prevention. Interim clinical guidance for management of patients with confirmed coronavirus disease (COVID-19). <https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-guidance-management-patients.html>. Accessed 9 May 2020.
- Center for Disease Control and Prevention. Interim Guidelines for Collecting, Handling, and Testing Clinical Specimens from Persons for Coronavirus Disease 2019 (COVID-19). <https://www.cdc.gov/coronavirus/2019-nCoV/lab/guidelines-clinical-specimens.html>. Accessed 10 May 2020.
- Ai T, Yang Z, Hou H, et al. Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 (COVID-19) in China: a Report of 1014 Cases. *Radiology*. 2020.
- The American College of Obstetricians and Gynecologists and Society for Maternal-Fetal Medicine. Outpatient assessment and management for pregnant women with suspected or confirmed novel coronavirus (COVID-19). https://s3.amazonaws.com/cdn.smfm.org/media/2263/COVID-19_Algorithm5.pdf. Accessed 10 May 2020.
- Society for Maternal-Fetal Medicine. Management considerations for pregnant patients with COVID-19. https://s3.amazonaws.com/cdn.smfm.org/media/2336/SMFM_COVID_Management_of_COVID_pos_preg_patients_4-30-20_final.pdf. Accessed 10 May 2020.
- Poon LC, Yang H, Dumont S, et al. ISUOG Interim Guidance on coronavirus disease 2019 (COVID-19) during pregnancy and

- puerperium: information for healthcare professionals - an update. *Ultrasound Obstet Gynecol.* 2020.
12. Society for Maternal-Fetal Medicine. Coronavirus (COVID-19) and pregnancy: what maternal-fetal medicine subspecialists need to know. [https://s3.amazonaws.com/cdn.smfm.org/media/2322/COVID-19-What_MFMs_need_to_know_revision_4-11-20_\(final\)_highlighted_changes._PDF.pdf](https://s3.amazonaws.com/cdn.smfm.org/media/2322/COVID-19-What_MFMs_need_to_know_revision_4-11-20_(final)_highlighted_changes._PDF.pdf). Accessed 10 May 2020.
 13. National Institutes of Allergy and Infectious Diseases. News release: NIH clinical trial shows remdesivir accelerates recovery from advanced COVID-19. 2020. <https://www.niaid.nih.gov/news-events/nih-clinical-trial-shows-remdesivir-accelerates-recovery-advanced-covid-19>. Accessed May 10, 2020.
 14. United States Food and Drug Administration. Recommendations for investigational COVID-19 convalescent plasma. 2020. <https://www.fda.gov/vaccines-blood-biologics/investigational-new-drug-ind-or-device-exemption-ide-process-cber/recommendations-investigational-covid-19-convalescent-plasma>. Accessed 10 May 10, 2020.
 15. Travers CP, Clark RH, Spitzer AR, Das A, Garite TJ, Carlo WA. Exposure to any antenatal corticosteroids and outcomes in preterm infants by gestational age: prospective cohort study. *BMJ.* 2017;356:j1039.
 16. Boelig R, Manuck T, Oliver E, et al. Labor and delivery guidance for COVID-19. *Am J Obstet Gynecol MFM.* 2020:1–10 (in press) Available online March 25, 2020.
 17. Solaimanzadeh I. Acetazolamide, nifedipine and phosphodiesterase inhibitors: rationale for their utilization as adjunctive countermeasures in the treatment of coronavirus disease 2019(COVID-19). *Cureus.* 2020;12(03):e7343.
 18. Society for Maternal-Fetal Medicine and Society for Obstetric Anesthesia and Perinatology. Labor and delivery COVID-19 considerations. 2020. https://s3.amazonaws.com/cdn.smfm.org/media/2327/SMFM-SOAP_COVID_LD_Considerations_-_revision_4-14-20_-_changes_highlighted.pdf. Accessed 10 May 2020.
 19. National Institutes of Health. COVID-19 treatment guidelines: special considerations in pregnancy and post-delivery. <https://www.covid19treatmentguidelines.nih.gov/overview/pregnancy-and-post-delivery/>. Accessed May 10 2020.
 20. Sutton D, Fuchs K, D'Alton M, Goffman D. Universal screening for SARS-CoV-2 in women admitted for delivery. *N Engl J Med.* 2020 <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7175422/>. Accessed May 10, 2020.
 21. The American College of Obstetricians and Gynecologists. COVID-19 faqs for obstetrician-gynecologists, obstetrics. <https://www.acog.org/clinical-information/physician-faqs/covid-19-faqs-for-ob-gyns-obstetrics>. Accessed 10 May 2020
 22. Center for Disease Control and Prevention. Considerations for inpatient obstetric healthcare settings. <https://www.cdc.gov/coronavirus/2019-ncov/hcp/inpatient-obstetric-healthcare-guidance.html>. Accessed 11 May 2020.